New LCA Theses

First PhD Thesis on LCA in Poland

Ecobalancing of Machines and Devices with the Example of Air Compressors

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Grzegorz Laskowski [1] (1999) began his Ph.D. research by focusing on the development of LCA methodology for the assessment of machines and devices. He wrote a dissertation with the main objective of how LCA may be applied to machines, in order to describe what methodological LCA issues are specific to these objects and to work out solutions to some of these issues. The title of this thesis addresses the term "ecobalance", a more common term in Poland than "LCA" [1].

The dissertation consists of ten parts. The problem of **man's influence on the environment through his products** (machines and devices) is undertaken in this work. The aim of the work is to prepare the comprehensive method of environmentally oriented analysis of these technical objects and to give the basis for their environmentally oriented, structural improvement. At the beginning, the **literature review** is performed. It is stated, especially for the Polish condition, that there are no satisfactory examples for the complex valuation of machines and devices which influence the environment. The areas in which this influence exists are shown. A **critical review** of ecobalancing methods is performed and the environmental life cycle assessment methods are chosen as being practicable for applying to machines and devices. Next, the outline of these methods and algorithms for machines and devices is presented.

In a further section of this dissertation, the **comparative life cycle assessment of selected technical objects** (air compressors) is performed using an elaborate method. Possibilities of application for the outcomes of an environmentally-oriented improvement of air compressors are reviewed. In addition, a means of pro-environmental improvement is presented for machines and devices on the basis of performed ecobalances on different construction materials and processes. This procedure can help to support decision making in the design stage of other technical objects.

For the comparison, **three types** of air compressors with similar yields are chosen. The typical two-step, one-sided action, air-cooled machine is selected as type A. The oil-less compressor with construction similar to type A is considered as type B, and a single-stage screw compressor with internal oil injection is analyzed as type C. As a functional unit, the production of 1 mm^3 of compressed air is used.

In this study, a comparative life cycle assessment (LCA) for air compressors is performed. The detailed tasks of this work were:

- identification of areas of the significant environmental impacts in the life cycle,
- description and comparison of environmental interactions of compressors,
- finding the possible improvement opportunities in the life cycle,
- comparison of results by different methods for LCA.

The selected compressors were compared by using the following criteria:

- environmental impacts in the life cycle of compressors with particular consideration of polluting emission,
- energy consumption in life cycle,
- material consumption as a utilization of the various materials in production and use.

The **system boundaries** have encompassed all stages of the life cycle including the exploitation of natural resources, the manufacture of materials, the manufacture of compressor elements, assembling of compressors, distributing, using (exploitation, maintenance, overhaul) of compressors and their liquidation.

Data was gathered from the production and operation units. Other data was derived from up-to-date reference manuals. After the analysis of the access to the data and their reliability, different impact categories were taken into account in the life cycle.

This is a study attempting to compare the environmental advantages of one compressor over another, and also life-cycle impact analysis to define a baseline for life-cycle improvement analysis. Some suggestions are given for the further environmentally-oriented optimization to aid compressor producers.

For analyzed compressors, the results of the LCA's clearly show that the **key environmental impacts** of the compressors were:

- use-power consumption is the most significant impact,
- manufacture – a component which used significant amounts of steel, cast iron and copper are the most important,
- energy consumption during manufacture.

The **description analysis** of environmental factors shows predominating fields in the life-cycle of compressors. In these areas, there are the greatest possibilities in the improvement

[1] *Grzegorz Laskowski* did his Ph.D. at Poznan University of Technology, Faculty of Machines and Vehicles and was promoted by Professor Zbigniew Klos from Poznan University of Technology.

of present conditions. The results of this study confirm the validity of some common ecodesign rules:
- using more efficient motors and to develop compressors which have a bigger efficiency,
- minimize the number of materials used,
- minimize the power consumption during the product's use,
- maximize the compressors "life".

Industry could use this case-study to make Polish designers be aware of the importance of environmental impacts of choices made in product design. Even small constructional changes leading to a diminishment of the energy consumption can strongly reduce environmental burdens caused by the use of comparable compressors. The results of the LCAs have been used to identify options to improve the current design of these technical objects.

The **final results** (indicators) obtained by using different LCIA methods are similar. However, when one takes into account results concerning materials and processes, one can notice some differences. For Ecopoints (NL), for example, the most significant environmental burdens are from copper materials, then electricity and process of non-ferro cast work. For Ecoindicator 95 and Ecopoints (CH), the most dominant are steel, cast iron materials and electricity consumption during process production. Results from normalization and valuation are not comparable because they concern different environmental classes.
The results obtained show that the screw compressor has the lowest detrimental influence on the environment. The main reasons are: simpler construction, lower weight and a life time which is three times longer. In this case, the forecasts of an increase in further market shares positively coexist with the better environmental parameters of this appliance. This is the case in spite of the much higher price of screw compressors on the local market.

In conclusion, the summing up of the results and directions for further research in the area of life cycle assessment are pointed out.

[1] Laskowski, G. (1999): Ekobilansowanie maszyn i urzadzen na przykladzie sprezarek powietrza. Ph.D. dissertation. Poznan University of Technology, Faculty of Machines and Vehicles, Poznan, Poland